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An Interdisciplinary Analysis of Multispectral Satellite Data for Selected Cover Types in the Colorado Mountains, Using Automatic Data Processing Techniques

EREP S398

Monthly Progress Report for October 1974

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Principal Investigations Management Office
Lyndon B. Johnson Space Center

Technical Monitor: Dr. Rigdon Joosten
Principal Investigations
Management Office
Johnson Space Center
Houston, TX 77058

Principal Investigator: Dr. Roger M. Hoffer

Laboratory for Applications
of Remote Sensing

Purdue University
West Lafayette, IN 47906

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(E75-10002) AN INTERDISCIPLINARY ANALYSIS OF MULTISPECTRAL SATELLITE DATA FOR SELECTED COVER TYPES IN THE COLORADO MOUNTAINS, USING AUTOMATIC DATA PROCESSING (Purdue Univ.) 7 p HC $3.25 CSCL 08F G3/43 N75-12390 Unclas 00002

MONTHLY PROGRESS REPORT
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A. Overall Status and Progress to Date

General

Attached are a series of viewgraphs and 35mm slides summarizing some of our accomplishments to date. Viewgraph 1 gives the projects included in our contract. Viewgraph 2 shows the types of data collected during SL-2 while slide 1 shows the MSS coverage during the summer of 1973.

Hydrological Features Survey

During October, John Dornbach, NASA/Houston, and Ruth Whitman, NASA/HQ, visited LARS to collect documentation on the advantages and capabilities of scanner data, including middle and thermal infrared data. The Hydrological Features Survey provided information to them documenting the need for middle infrared scanner data for making accurate snow surveys.

Slide 2 is a simulated color IR photo of ERTS data (1299-17205) indicating fields of snow and clouds. Viewgraph 3 is a statistical comparison and demonstrates that ERTS cannot distinguish clouds from snow.

SKYLAB, however, contained a MSS with a greater spectral range than ERTS. The S192 provided a significant advantage, particularly because of its capability to obtain data in the middle IR portion of the spectrum. Slide 3 shows all 13 wavelength bands and graphically presents how the snowpack appears to diminish in area as wavelength is increased. This phenomenon is believed to be caused by a higher liquid water content in the snow near the edges of the snowpack, where the snow is melting at the lower elevations, and also the increasing vegetation density at lower elevations and in the areas where the snowpack is not as deep. Slide 4 is a simulated color IR (bands 3, 5 and 8) of SKYLAB MSS data containing both snow and clouds. Slide 5 shows how the spectral response of snow and clouds vary through the spectrum. Viewgraph 4 is a statistical comparison using the approximate ERTS bands and a middle and thermal IR band. Note that this graph clearly demonstrates that only the middle IR portion of the spectrum can reliably separate snow and clouds.

The reason for this is that the spectral responses of clouds (thick Cumulus type) and of fresh snow are very high and quite similar throughout the visible and part of the reflective infrared portion of the spectrum. This causes problems in the spectral differentiation of clouds and snow using remotely sensed data. The two major reasons for this are: a) their spectral characteristics are very similar in these wavelengths, and b) the fact that such a high "reflectivity" saturates the response of the detectors, as it is the case with the ERTS-1 system. However, in the middle infrared portion of the spectrum, the spectral response of clouds diverges considerably from that of snow. The clouds still continue to show a high response up to a wavelength of 2.35 μm, while the snow shows an appreciable drop in reflectivity for wavelengths between 1.3 and 2.5 μm. It should be noted that this middle infrared portion of the spectrum (1.3 - 2.5 μm) cannot be detected by photographic emulsions or by means of the ERTS-1 MSS sensor system. On the other hand, the SKYLAB S192 MSS system is capable of detecting radiation in this middle infrared region in two discrete wavelength bands (1.55-1.75 and 2.10-2.35 μm) where differentiation and identification of snow and clouds can be accomplished on the basis of spectral information only.

Such different spectral behavior between snow and clouds in the middle infrared portion of the spectrum, even though they are composed of the same substance - water -- may be accounted for through the following physical considerations.

The high spectral response of a snow surface in the visible and near infrared portion of the spectrum can be attributed to multiple reflections from the small ice crystals composing the plate-like snow flakes. In this case, the spectral response can be considered as a true reflectance phenomenon. Furthermore, for high angles of incidence and near zenith detection angles, the snow surface can be regarded as an excellent natural diffuser or Lambertian surface. When considering snow at the microstructural level, one is actually dealing with the structure and physical characteristics of ice. The spectral characteristics of ice have been thoroughly studied and found to be practically the same as those for liquid water, including the position, width and number of absorption bands. Thus, it is clear that for increasing wavelengths, especially in the middle infrared region, the absorption of the ice plates that form the snow flakes will dominate and consequently reduce the reflection component. This is so true that as one moves into the thermal infrared portion of the spectrum, the snow surface absorbs about 100% of the incident radiation; that is why the snow surfaces are considered to be one of the most perfect natural radiators (black-bodies).

The high spectral response of clouds throughout the visible and near reflective infrared portion of the spectrum is caused by a different physical phenomenon than that for snow. It is actually an intense non-selective scattering effect in which the water droplets that form the clouds act as scattering centers effective in all wavelengths of the reflective portion of the spectrum, because their sizes are considerably larger than any of the wavelengths involved.

Ecological Inventory

The June 5, 1973 ERTS-1 data (scene ID 1317-17204) has been overlayed onto a U.S.G.S. 1:24,000 scale map base, and this data will be used as the base data set. The SL-2 S192 data is in the process of being overlayed onto the coordinate system of the base data. By accomplishing this, it will be possible to establish one set of training areas and one set of test fields to use in evaluating the classification accuracy and comparing the different MSS data sources. This overlay of the SL-2 S192 unfiltered data on the data base is expected to be finished during the next reporting period. The digitized topographic data will also be overlayed onto this data base. A similar procedure, including overlay of the digitized photographic data, will be attempted with SL-3 data.

The process of defining test fields on the data base is currently being undertaken. To select test fields, a systematic grid of cells (4 by 4 resolution elements) were located on a 9 resolution element interval over the entire Granite Peaks Study Area. Each of these cells are defined as potential test fields. This type of sampling interval yields a possible test sample of 19.75 percent of the total data set.

To eliminate any potential test fields that contained more than one cover type, the cover type maps generated by INSTAAR were placed over a gray scale printout of the data base which had all of the potential test fields outlined. Because of the difficulty in accurately (within one resolution element) overlaying the cover type maps, a one resolution element buffer strip was added to each potential test field. Any potential test field (plus buffer strip) which had a type line crossing the test field was eliminated from further consideration as a test field. This process reduced the number of potential test fields to approximately 620, which will yield a 5 percent test sample.

The next step which is in progress at the current time is to identify each test field using the cover type map and double check the test field identification using the color infrared aerial photography.

Topographical Study

A test overlay of USDMA digitized topographic data was completed during the period (see slide 6). Topographic data was taken from a 1:250,000 scale map of the Durango quadrangle with a contour interval from the map of 200 feet. The cell size for the topo data is 210 feet square. The ERTS cell is 260 feet square. Thus the scales are fairly comparable. This particular topo tape contains elevations from 5924 feet (darkest gray scale) to 14,250 feet (whitest gray scale), rescaled to 0-255 to fit in the LARS tape format. Thus the increment of the elevation values on tape is 32.5 feet. Nearest neighbor interpolation was used and since the scale ratio of ERTS versus topo is 260/210 = 1.24, certain topo values are duplicated, such that in 100 samples 24 are duplicated.

Work was begun on an overlay of SKYLAB S-192 data onto ERTS MSS data for the Durango area. Rotation of the S-192 data to north is in progress and will be somewhat difficult since the rotation is around 45^{o}. Topographic data, ERTS data and S-192 data will be overlayed forming an 18 channel tape.

Planning was carried out for adding slope and aspect to the topo data as two extra channels. Presently available programs may be usable to compute these values.

Elevation, slope and aspect are all known to have significant impact on the type and density of vegetation. These parameters should therefore increase classification accuracies.

Geological Assessment

Slides 7 and 8 show two methods for locating the gossen, or alteration zone associated with certain types of ore deposits, particularly hydrothermal lead, zinc, silver and gold vein deposits.

The gossen is distinctly colored and therefore readily lends itself to spectral analysis. Slide 7 shows the resulting LARSYS classification.

Slide 8 shows a method for enhancing the gossen. A colored image using ratioed channels has made the gossen a distinct orange-red. An advantage of this method is that the effects of slope, aspect and shadows are reduced to a minimum allowing the gossen to be observed in areas where classification is more difficult.

B. Recommendations

The SL-3 S192 data should be sent to LARS as soon as possible.

C. Expected Accomplishments

The snow-cloud differentiation project will be written-up and submitted for publication. Before submission it will be sent to the Technical Monitor for clearance. Attention will now turn to completing the other objectives of the Hydrological Features Survey.

The S-192 data will be rotated to a north-south orientation to enable it to be overlayed on the topographic and ERTS data.

During the next reporting period the test field selection should be finished and analysis of the SL-2 S192 data for forest cover types will be in progress.

D. Significant Results

This report provides documentation of capability of the middle infrared portion of the electromagnetic spectrum to spectrally differentiate clouds from snow. Other portions of the spectrum cannot provide this capability.

E. Summary Outlook

The vegetation and hydrological features activities will concentrate on analysis of the unfiltered SL-2 S-192 data obtained over the San Juan Test Site. Geologic analysis activities need the SL-3 S-192 data, and until such data is available this effort will concentrate on the relationships between digitized photographic data and spectral response on the aircraft scanner data. The topographic analysis activities will concentrate on rotating and overlaying the S-192 data and the topographic data onto the base data set. Slope and aspect programs will be examined for potential usefulness within this overlayed data set.

F. Travel

There were no travel funds expended from this contract during this reporting period.

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Visual Materials Description

Sequence	Slides	
3	S-1	MSS coverage
4	S-2	Color IR ERTS w/snow & cloud fields
6	S-3	13 λ bands
7	S-4	Color IR 192 w/snow & cloud fields
8	S-5	6 λ bands w/snow and cloud
10	S-6	Topographic data
11	S-7	Geology class
12	S-8	Geology ratios
	Viewgraphs	
1	V-1	Projects
2	V-2	Types of data collected during SL-2
5	V-3	Statistical comparison S&C fields ERTS
9	V-4	" " " " SKYLAB